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ABSTRACT

In this research, we investigated the effect of peer instruction method on the first course mathematics education students' academic achievement and the attitudes of students using peer instruction method. The implementation was carried out 15 weeks with 60 participants in an introduction to mathematics analysis lesson in Suleyman Demirel University in Kazakhstan. Two first course group were randomly assigned to treatment and control groups. The final results were obtained to measure students' academic achievement and questionnaires used to indicate attitudes towards peer instruction. Data were analyzed using t-test ($p=0.029$). The results of final questions indicated, peer instruction has a significant positive effect on students' achievement in the introduction to mathematics analysis course and the results of questionnaires demonstrated PI has a positive impact on peers' understanding and PI makes a good atmosphere in the class.

Introductıon

Instructors use the traditional teaching method to transfer their knowledge to students in many different disciplines and courses. They have difficulties in problem solving, deriving relationships, knowledge of representations, and conceptual learning in these teaching methods (Crouch and Mazur, 2001; Savelsbergh, de Jong and Ferguson-Hessler, 2011; Thompson, Christensen, and Wittmann, 2011). According to Freeman (2014) "students in classes with the traditional methods have 1.5 times higher chances of failing than students in active teaching method ". Therefore, researchers have been developing new teaching approaches and models based on active and interactive learning for a long time. One of these approaches is peer instruction. Mazur and Watkins

(2010) defined peer instruction as “An active teaching method that promotes classroom interaction to engage participants and address difficult aspects of the material.” In general, peer instruction is a student-centered active learning method in which students share their knowledge by interacting with each other instead of transferring information from the teacher (Kwan and Wong, 2015). This method changes the pattern of the lecture format from the traditional one to one in which the instructor poses multiple-choice questions during the course, thereby engaging students actively in discussions with their classmates and focus their attention on central concepts (Crouch et al. , 2007; Crouch and Mazur, 2001; Mazur, 1997) Porter, Lee, Simon, and Zingaro (2011) described the peer instruction as "students one by one response a question, discuss with group mates, and response to the same question again.". Instructors have noticed that peer instruction enhances depeer understanding of the students by making the class lively and interactive (Crouch, 2007; Crouch and Mazur, 2001; Mazur, 1997). Crouch and Eric Mazur (2001) indicated that the peer instruction develops the students’ understanding. According to Akay (2011) in the model of peer instruction, students learn and teach themselves while their friends in a similar social group help them to learn. For this reason, it is thought that the information learned can leave more permanent marks on the students and give students the power to comment. Peer instruction can be defined as a method in which students are actively involved in the education process by discussing within a peer group and helping each other within the group. (Crouch and Mazur, 2001; Mazur, 1997; Nicol and Boyle, 2003). Peer instruction is fast, fun and supportive. Therefore, it has a positive effect on the success of students. Students reach information by doing and living. Since knowledge and skills are students' own work, they also affect permanence in a positive way. In summary, in peer teaching method, students think, analyze, discuss, and challenge on the materials with classmates while on the other hand, the instructors create a conducive learning atmosphere, observe the classroom, listen to students and ensure the real-time feedback. Peer instruction was first applied in teaching fundamental physics concepts using multiple-choice tests in a crowded physics course (Mazur, 1997). Until now, several studies on peer instruction method have been published in different courses and disciplines. Studies focused on academic achievement, motivation, self-confidence, problem solving, attitude towards mathematics, retention and conceptual understanding. The results of previous studies on achievement in physics (Crouch and Mazur 2001; Gok, 2012; Harvey, 2013; Lasry et al., 2008; Lorenzo, Crouch and Mazur 2006; Miller-Young, 2013), in chemistry (McCreary, 2006; Trent, 2013), in computer science (Simon, Spacco and Parris, 2013; Zingaro and Porter, 2014), in the medical physiology course (Rao

and Di Carlo, 2000), in the English course (Yaoyuneyong and Thornton, 2011).

The Implementation of PI

The application of PI method includes seven steps. Initially, the instructor gives a short lecture on a concept in the course, it takes 15-20 minutes.Then, the instructor gives concept test questions; concept test questions are designed to evaluate the student understanding of the basic concepts behind the lecture material. Students solve the question individually and give first responses in 2-3 minutes. After that the instructor analyzes responses if the correct answers are less than 30%,the instructor explains the lecture again, if the correct answers are between 30% and 70%, the class passes the discussion part and if the answers are higher than 70%, the instructor presents the next question. In the fourth step, students discuss their answers with classmates in 1-2 minutes. The previous studies (Brooks and Koretsky 2011; Catherine H. Crouch and Eric Mazur 2001; Lasry 2009) indicated that the discussion section is an important part of peer instruction and it affects the students' responses positively. After the discussion part, students give second responses. In the last step, the teacher collects answers and explains the question. The students vote sometimes using colored cards or a show of hands instead of the clickers—the general process is an adaptation of the think–pair–share technique. (Knight and Brame 2018).

The concept test proceeds as follows:

1. To give questions
2. Participants are given time to think
3. Each participant gives an answer
4. Participants discuss their responses with classmates
5. Participants give second responses
6. Instructor collects answers
7. Instructor explains correct answers

(Fagen, Crouch, Mazur, and Watkins 2007)**.**

Peer Instruction in Math Classes

Although the first application of PI in classrooms was done in a physics course, peer education has been spread and used in other disciplines. In

addition, several works which are applied in maths also indicated the successful results. In our literature review, we investigated 23 studies in mathematics. Several studies were researched in academic achievement (Abdelkarim and Abuiyada, 2016; Abdelkarim, Abuiyada and Siddiui, 2016; Akay, 2011; Allison, 2012; Cronhjort, Filipsson and Weurlander, 2013; Demirel, 2013; Oloo, Mutsotso and Masibo, 2016; Ouko, Aurah and Amadalo, 2015; Vasay, 2010; Yavuz, 2014) , their results demonstrated that peer instruction affected the students' academic achievement positively. The results of studies about attitudes towards mathematics (Abdelkarim, Abuiyada and Siddiui, 2016; Akay, 2011; Campit and Garin, 2017; Demirel, 2013; Yardim, 2009) showed peer instruction has a positive impact in attitudes towards mathematics. Allison (2012) study indicated that peer instruction affected motivation positively. The other studies results showed positive effect Awinoouko (2018) in problem solving ability, Pilzer (2007) in academic math skills, in the attendance Olpak, Baltaci and Arican (2018), in proficiency level in mathematics Lacaba, Magalona and Lacaba (2018) and, in retention Demirel (2013).

Purpose of the Study

The purpose of the study is to investigate the impact of peer instruction in first-course mathematics education in the introduction of mathematical analysis class.

Research Question

1. Does peer instruction have any effect in the introduction of a mathematical analysis class?
2. What is the effect of attitudes towards peer instruction teaching procedure during lectures on peer group?

Methodology

The participants in this study were 60 students (34 girls and 26 boys) aged 18-21 years in the education mathematics course. None of them had used colored cards in their studies, and they had never studied with peer instruction teaching procedure before.

Materials

Final questions: The final question includes the topics for 7 weeks in the syllabus. It contained 10 questions which were prepared by the researcher.

Questionnaire: The survey, which was done before the other study (Al-Hebaishi, 20017), contained 18 items based on a five-point Likert-scale; 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree.

Procedure

Initially, the instructor provided the students instructions on how to use PI during the class. The application of PI was carried out as defined by Lymma (1981) and Mazur (1997). In the first course curriculum introduction to mathematical analysis has 3 hours. Each class included two parts, the first part of 15-20 minutes of the class was for the lecture while PI was carried out in the other part of the class. For the PI, initially, the lecturer presents the question and two minutes were given to the students, to think and solve the concept test question individually. Then, students gave first responses by using colored cards and the result was shown on the screen as a histogram. After analyzing the histogram, students discuss their responses with their peers in two minutes. In the discussion part, students provide their reasons and try to convince their peers that their responses are correct. Several studies indicated that the discussion part of peer instruction increases correct answers.

Figure 1 illustrates the alteration of students' responses that during the discussion change from an incorrect answer to the correct answer. Catherine, Crouch & Mazur (2001).

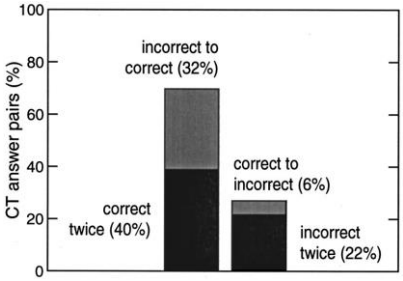

Figure 1. Change of answers

After discussion with their peers, the students were given the opportunity to change their first answers if they desired in 1 minute. The instructor presents the histogram of second responses and students observed it. Lastly, the instructor explains the correct answer of the question in two minutes.

In the Implementation, if after the first response, the correct answers are less than 30%, the instructor gives the lesson again, if the correct answers are between 30% and 70%, then the peer instruction method is implemented and if

correct answers are more than 70%, pass on to the next question (Lasry et al., 2008).

Histogram of the first and second answers of the question asked in the figure below is given.

Which of the following expression are true? (Since there may be more than one correct answer, determine all correct answers.)

A-If $\lim_{x\to a}\frac{f(x)-f(a)}{x-a}$ *exists, then f is differentiable at a.*

B-If f is continuous at a, then f is differentiable at a.

C-If $\lim_{x\to a} f(x)$ *exists, then f is differentiable at a.*

D-If is differentiable at a, then $\lim_{x\to a} f(x) = f(a)$

A- Only A
B- A and C
C- C and D
D- A and D
E- B and C

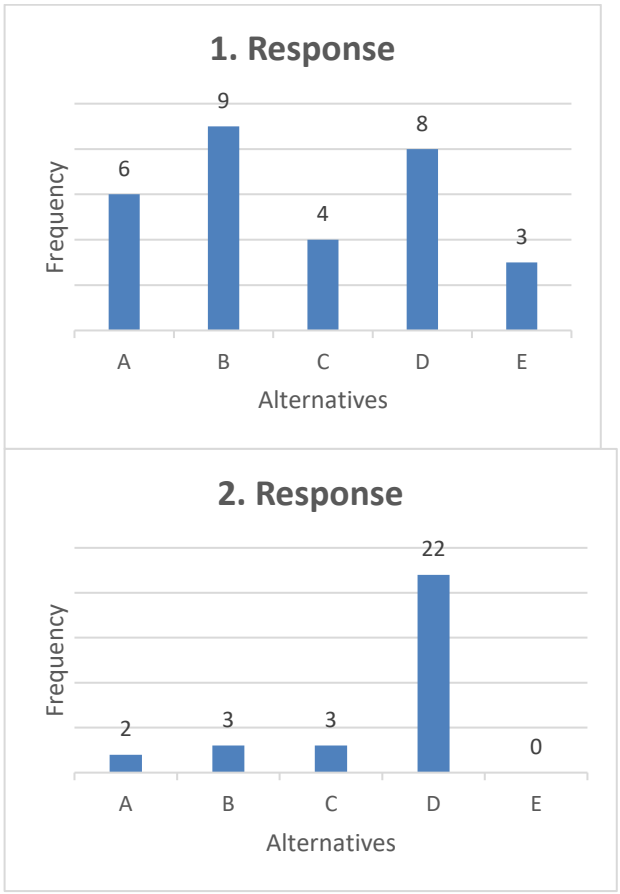

Figure 2. A typical graph for students' first and second responses. The correct answer is D.

As seen in Figure 2, the frequency of the correct reply increased from 8 to 22 while the frequency of the wrong reply decreased significantly.

Results

Findings Regarding the Final Questions

Table 1. Group Statistics

groups	N	M	sd
Traditional	30	68.67	25.90
Peer	30	81.00	15.28

The mean of the group who received traditional instruction was 68.67 while the mean of the peer instruction group was 81.00 (See Table 1). This result shows a significant difference on behalf of the peer instruction group. The statistically significance was checked by independent sample t test (Table 2).

Table 2. Independent sample t test results

t	df	p	Mean Difference
-2.25	58	.029	-12.33

The t test results indicate that peer instruction has an effect on students' achievement (t (58) =-2.25, p=0.029).

Findings Regarding the questionnaire

Table 3 indicated the statistical illustrative examination of the attitudinal survey implemented to the treatment group at the end of implementation, which was planned to gain comprehension into their feelings regarding peer instruction teaching procedure.

Table 3. Examination Results of the attitudinal survey implemented to the treatment group

Item	N	Mean	SD
1	30	4.467	0.718
2	30	4.067	0.964
3	30	4.267	0.680
4	30	3.967	0.983
5	30	4.367	0.699
6	30	3.867	0.991
7	30	3.733	0.093
8	30	4.300	0.640
9	30	4.367	0.657
10	30	4.033	0.772
11	30	4.500	0.563

12	30	4.067	0.907
13	30	4.000	0.775
14	30	4.633	0.806
15	30	1.800	0.833
16	30	3.967	0.875
17	30	4.233	0.629
18	30	4.300	0.690

The outcomes of the analysis of the survey showed mean scores between 4.633- and 1.8000. The top mean score was achieved from Item 14 (M = 4.633), showing that 99% of the participators trust that the students should offer help to develop their group mates' learning.The second maximum mean score was achieved from Item 11 (M = 4.500), which demonstrates that approximately 97% of the peer instruction group thinks that the peer instruction method established a sincere interrelation among students. Item 1 achieved the third highest mean score (M = 4.500), signifying that 89% of the participators trust that PI creates a supportive ambiance in the classroom. Items 5 and 9 achieved an equal mean score (M = 4.367), and jointly reached a fourth place ranking, thus, revealing that 90-95% of the peer instruction group either agreed or strongly agreed that using the peer instruction method makes courses interesting and increases the interaction among students. Lastly, item 15 obtained the lowest score mean (M = 1.800), showing that 70% of participants don't agree that discussion with group mates does not help students to learn. In general, the treatment group had a positive attitude towards the peer instruction teaching method and realized it is helpful in making possible for them to understand key course concepts (Table 2).

Discussions

The present study examined the effect of the peer instruction procedure on the first-course education math students in an introduction to mathematics analysis course at Suleyman Demirel University with 60 students. A final quiz consisting of 10 questions was prepared by the author to measure the success of the students. The peer instruction procedure was applied in teaching course concepts to the treatment group while the comparison group was exposed to the traditional instruction method approach. According to statistical analyses, there were statistically significant differences between both groups' average mean final scores. This study is distinctive from other similar studies on this topic in that, it is the first study guided in Suleyman Demirel University.

The results of this study support other research, which approves that PI improves student performance and learning. For instance, Crouch and Mazur (2001) found significant rises in conceptual problem-solving skills across 10-year duration of peer teaching experience in physics classes. Likewise, Rao and Di Carlo (2000) noticed that PI developed medical student achievement on quizzes. Similarly, Lucas (2009) reported that PI increases student participation and understanding. As a final example, Cortright, Collins, and Di Carlo (2005) found that a student's ability to solve novel problems was significantly improved after the PI.

According to Porter and Zingaro (2014), the peer instruction procedure is a collaborative pedagogical application within course lectures. This procedure has delivered important development in the final examination performance of the students by actively engaging the students in deepening their understanding from the instructor's explanation to establishing their own learning patters. Therefore the rates of failures were observed decreasing and students were being retained (Simon et al., 2013). This procedure is being implemented in a wide field of science courses, mathematics, and other branches at the secondary education, colleges, and university. (Mazur, 2013).

Peer instruction teaching procedure makes a supportive learning atmosphere wherein participants support each other during the learning procedure, and cooperate in order to establish information and reach a comprehension regarding crucial concepts (Al-Hebaishi, 20017). According to the study conducted, most of the participants strongly agree that students should assist each other to improve their peers' learning. Moreover, the majority of the participants strongly agree that PI creates a friendly relationship among students inside and outside the classroom environment thus leading to a supportive atmosphere in class. In addition to that, most of the participants from the study conducted strongly agree that PI makes the course interesting and also increase interaction among the students. The majority of the participants also strongly disagreed that oral discussion with group mates does not help students to learn.

Conclusions

In summary, according to the study conducted, PI teaching procedure improves significantly the learning of the students as well as of peers compared to traditional teaching method. We found a significant increase in students' performance, similar to the study overseen by Crouch and Mazur (2001), they observed that learning gains doubled when using PI than when

using traditional lecture procedure. The results of the survey demonstrated, PI builds a conducive learning environment by making learning interesting and interactive. The participants think that PI is an effective teaching method for their career. PI opens up classroom discussion among students and their peers making the class active and lively, this leads to effective learning among the students as comprehensions and understanding is enhanced (Simon et. al., 2010).

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References

1. *Akay (2011). The effect of peer instruction method on the 8th grade students' mathematics achievement in transformation geometry and attitudes towards mathematics. Unpublished master thesis, METU, Ankara.*
2. *Al-Hebaishi, S. M. (2017). The Effect of Peer Instruction Method on Pre-Service Teachers' Conceptual Comprehension of Methodology Course. Journal of Education and Learning, 6(3), 70-82.*
3. *Allison, T. H. (2012). The impact of classroom performance system-based instruction with peer instruction upon student achievement and motivation in eighth grade math students. Retrieved from https://digitalcommons.liberty.edu/cgi/viewcontent.cgi?article=1526&context=doctoral*

4. *Awinoouko. Peer Instruction and Secondary School Students Problem Solving Ability in Mathematics; Bungoma County; Kenya. IOSR Journal Of Humanities And Social Science (IOSR-JHSS) Volume 23, Issue 2, Ver. 9 (February. 2018)*
5. *Brooks, B. J., & Koretsky, M. D. (2011). The influence of group discussion on students' responses and confidence during peer instruction. Journal of Chemical Education, 88(11), 1477-1484.*
6. *Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. American journal of physics, 69(9), 970-977.*
7. *Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410-8415.*
8. *Knight, J. K., & Brame, C. J. (2018). Peer Instruction. CBE—Life Sciences Education, 17(2), p.fe5.*
9. *Lasry, N., Finkelstein, N., & Mazur, E. (2009). Are most people too dumb for physics? The Physics Teacher, 47(7), 418-422.*
10. *Mazur, E. (1997). Peer instruction (pp. 9-18). Upper Saddle River, NJ: Prentice Hall.*
11. *Mazur, E., & Watkins, J. (2010). Just-in-time teaching and peer instruction. Just in Time Teaching Across the Disciplines, 39-62.*
12. *Pilzer, S. (2001). Peer instruction in physics and mathematics. Problems, resources, and issues in mathematics undergraduate studies, 11(2), 185-192.*
13. *Porter, L., Bailey Lee, C., Simon, B., & Zingaro, D. (2011, August). Peer instruction: do students really learn from peer discussion in computing? In Proceedings of the seventh international workshop on computing education research (pp. 45-52).*
14. *Savelsbergh, E. R., de Jong, T., & Ferguson-Hessler, M. G. (2011). Choosing the right solution approach: The crucial role of situational knowledge in electricity and magnetism. Physical review special topics-Physics education research, 7(1), 010103.*
15. *Thompson, J. R., Christensen, W. M., & Wittmann, M. C. (2011). Preparing future teachers to anticipate student difficulties in physics in a graduate-level course in physics, pedagogy, and education research. Physical Review Special Topics-Physics Education Research, 7(1), 010108.*

16. *Olpak, Y. Z., Baltaci, S., & Arican, M. (2018). Investigating the effects of peer instruction on preservice mathematics teachers' achievements in statistics and probability. Education and Information Technologies, 23(6), 2323-2340.*
17. *Lacaba, A. B., Magalona, J. D., & Lacaba, T. V. G. (2018). "Peer Teaching Strategy To Increase Mathematics Proficiency Level"(An Action Research)(Eastern Samar State*
18. *Cortright, R. N., Collins, H. L., & DiCarlo, S. E. (2005). Peer instruction enhanced meaningful learning: ability to solve novel problems. Advances in physiology education, 29(2), 107-111.*